GYPSY MOTH NEWS

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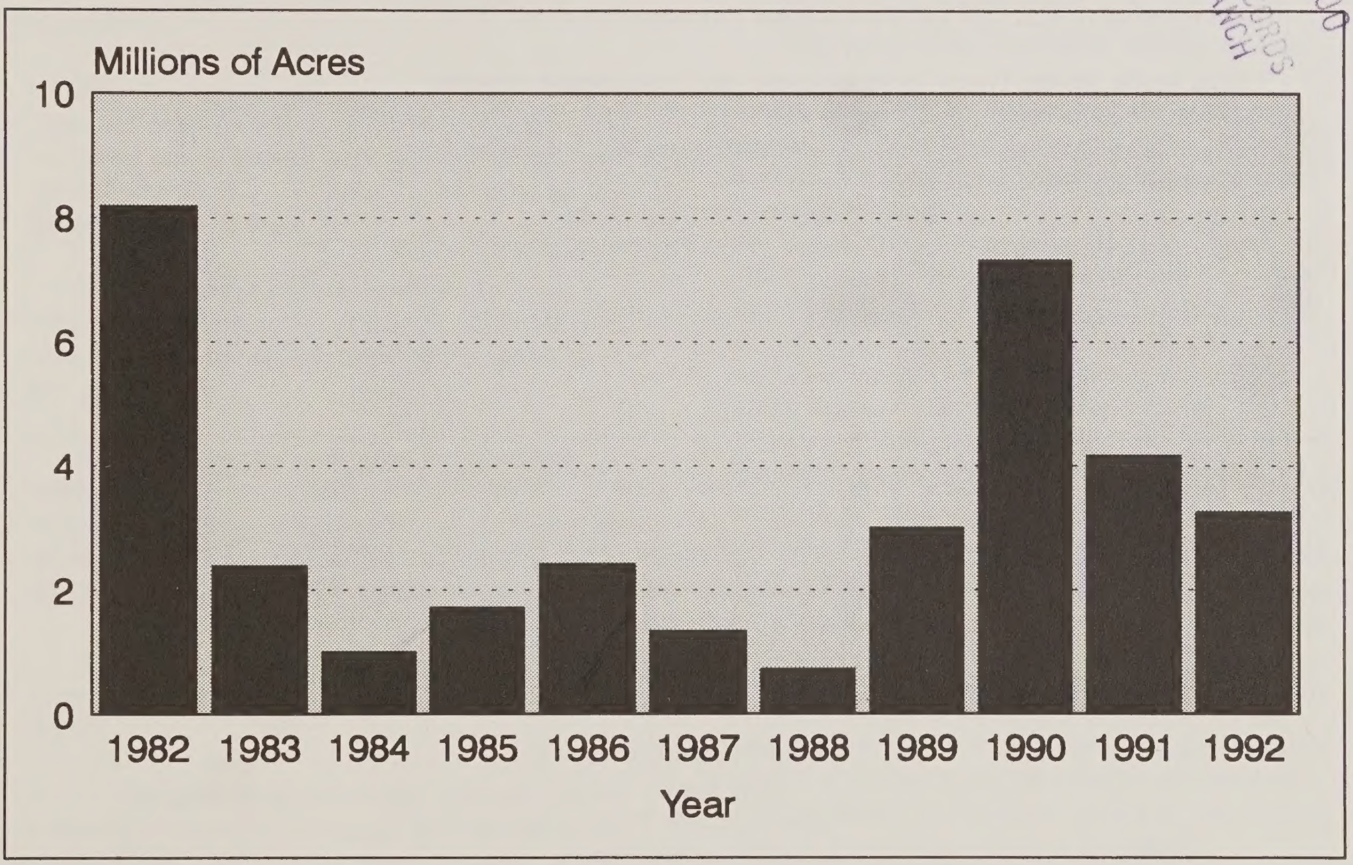
Gypsy Moth Defoliation in the USA



Source: GMDigest, Forest Health Protection, Morgantown, WV.

This issue features:

- **USDA Research Titles**
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GYPSY MOTH NEWS is a service of the USDA Forest Service, Northeastern Area State and Private Forestry.

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FROM THE EDITOR

In 1971, the USDA directed $1 million for gypsy moth research. Much of this was designated for cooperative studies with universities. Additionally the Forest Service and Agricultural Research Service (ARS) increased base funding and resources for gypsy moth research and development. Major areas of emphasis were 1) development and evaluation of new synthetic sex attractants; 2) increase exploration for foreign parasites and predators; 3) development work on microbial controls; and 4) efforts to analyze and predict changes in populations and their effect on the environment.

In 1975, this research effort was expanded. The expanded program was intended to complement and accelerate efforts already underway and to achieve specific objectives. The goals for the expanded program, 1975-78 were:

1. Methods for predicting population trends using new techniques for measuring larval dispersal, sampling egg masses and pupae, and monitoring low populations.

2. Procedures for measuring and predicting impacts by refining methods for measuring defoliation, relating defoliation to tree mortality, and developing additional technology for measuring socioeconomic and environmental impacts.

3. Safety and efficacy tests to evaluate and support registration of nucleopolyhedrosis virus (NPV).

4. Optimum formulations and application technology for use of chemicals, *B.t.*, and NPV.

5. Disparlure's use in containment, and suppression.

6. New chemical insecticide candidates screened and evaluated.

7. The effectiveness of available and newly introduced parasites.

8. Sterile male techniques evaluated for their potential as suppressive or population elimination tools.

9. A mass-rearing capability adequate for future program support.

Then in 1984, the current gypsy moth research and development program was created in the Northeastern Forest Experiment Station. The "new" program was directed at an integrated pest management approach which stressed maintaining gypsy moth populations at low levels. Program objectives again included:

- Mass-rearing technology
- The use of sex attractants for monitoring
- A procedure for classifying stand susceptibility
- Registration of GYPCHEK, a microbial pesticide, and Dimilin, a chemical growth regulator

In this issue, Max McFadden outlines another charter for Forest Service directed gypsy moth research and John Cunningham summarizes current Canadian research.

What research has been done to solve the gypsy moth problems you have? Look for titles related to your interest in this issue. Then write to: Assistant Station Director, M. McFadden, USDA Forest Service, 5 Radnor Corporate Center, 100 Matsonford Road, Suite 200, Radnor, PA 19087; Richard Reardon, USDA Forest Service, 180 Canfield Street, Morgantown, WV 26505; or John Cunningham, Forests Canada, Forest Pest Management Institute, Sault Ste. Marie, Ontario, Canada P6A 5M7.

Also note that the Annual Interagency Gypsy Moth Research Forum is scheduled for January 19-22, 1993, in Annapolis. This program features research review, poster sessions, and keynote presentations. Contact Katherine McManus, USDA Forest Service, 51 Mill Pond Road, Hamden, CT 06514.

-- DBT

LETTERS TO THE EDITOR

DHD from Columbus, OH asks:

> **"Is anyone pursuing the specificity of *B.t.* toxins against Asian Gypsy Moth? If so, is the spectrum; CryIAa, CryIAb, > CryIAc, as EGM?**

Normand Dubois, USDA Forest Service, Hamden, CT, responds:

"All we have to date is that Asian gypsy moth is as or slightly more susceptible than the European gypsy moth to the *B.t.* standard and to Foray 48B, both of which contain the 3 cryia ICP's. Sensitivity to each ICP will be done when we have enough larvae."

JM from Caro, MI, asks:

> **"I would like information on dealing with gypsy moth in a non-residential woodlot--i.e., forest management."**

Steve A. Katovich, USDA Forest Service, St. Paul, MN, responds:

"This is a very important yet difficult subject to discuss since the proper management strategy for any specific woodlot depends on many varied factors. These factors include the composition of a woodlot (i.e. is it mostly oak trees or is it made up of other species, such as maple or pine). Are the soils sandy, which will probably limit your options to basically pine and oak management, or are they heavier, rich soils which will allow you to manage for hardwoods such as maple, ash and basswood? Another major factor will be the management goals of the woodlot owner. Do they wish to manage for wood fiber production or do they wish to manage strictly for maximum wildlife habitat? If they are interested strictly in songbird management, then dying and dead trees may be beneficial to their goals. The answers to these questions will be very important in determining their options.

Despite the complexity of your question, I will attempt to give you some guidelines for certain situations. Let us assume that the landowner wants to reduce the likelihood of their woodlot being defoliated by gypsy moth, and if defoliation does occur they want tree decline and death to be limited. We will assume that the woodlot has quite a bit of oak in it.

Before getting into specifics, let's bring out a couple of important points. First, oak and aspen trees play a vital role in the development of young gypsy moth caterpillars. If a woodlot in Michigan does not have a large component of oak or aspen, it probably will not be heavily defoliated by gypsy moth. Therefore, any forest management program aimed at reducing the threat from gypsy moth must consider the amount of oak and aspen present in the woodlot. <u>If oak and aspen make up an appreciable proportion of the stand, then that proportion should be reduced</u>. If it is not reduced, the landowner must be willing at some point to accept tree mortality or be willing to protect the stand with an insecticide whenever an outbreak occurs.

The next important point is that <u>healthy, vigorous trees can survive defoliation better than weakened trees.</u> Properly thinning stands to reduce competition between individual trees should increase stand health. The proper thinning regime and the timing of the thinning will vary with the stand makeup and the local gypsy moth population. If the stand has well defined dominant oak trees and many other intermediate or suppressed oaks, you should thin to remove the oaks with smaller, overtopped crowns. If you have a choice between removing an oak and another species such as white pine, ash or maple, favor removal of the oak. This type of stand can be thinned at any time except during the years of peak defoliation. Do not thin any oak stands during an outbreak, since the actual thinning can cause a short-term stress which could actually increase tree mortality.

Oak stands which are not well stratified, which means that all the trees are relatively the same size and their crowns are equal in size and stature should be handled differently. In these stands, thinning should be done on the basis of spacing. Each tree which will be kept for the future stand should be provided adequate space to expand its crown. These stands should <u>not</u> be thinned a year or two before a large outbreak occurs. The reason for this is that it takes longer for these stands to recover from the shock of thinning. It is, of course, sometimes difficult to predict outbreaks in local areas.

Michigan woodlot owners will find it difficult to maintain forests made up primarily of oak and aspen. This does not mean that every oak or aspen should be removed. What it does mean is that pure oak forests should be discouraged in favor of more mixed stands and that where oak trees are growing they should be maintained at peak health using thinning and other forest management practices.

If you feel uncomfortable providing advice on forest management, I would strongly encourage you to recommend that woodlot owners seek advice from a reputable, professional forester. Forest management research is continuing in order to determine the "best" management practices for Michigan woodlots. Hopefully, in the very near future, more refined management guidelines will be developed.

WTR from Lyndhurst, VA, asks:

"I reside (with 60 other families) in an 850 acre development in an oak/hickory forested area of central Virginia. Our Homeowners Association decided to spray Dimilin to try and protect out property. We did so during the second week of May. My questions is: How long does Dimilin protect an area after spraying? It kills initially, but is it gone and useless after the first rain? Some areas around us are heavily infected. Will we have to spray again as the larva move in search of food?"

John Ghent, USDA Forest Service, Asheville, NC, responds:

"Dimilin is very persistent on foliage. The manufacturer reports a half life, the period of time required to reduce the active ingredient by half, as 45 days. Residue levels of the chemical can be found on leaves until leaf fall. The gypsy moth is very susceptible to the effects of Dimilin, although the effective dose is not known. Rates as low as .25 ounces per acre of active ingredient have shown to be as effective as .5 ounces per acre. Since your neighborhood was treated at the .5 rate, and we assume a half life of 45 days, protection by Dimilin from gypsy moth would last all season.

Dimilin is difficult to dissolve in water and is therefore not easily affected by rain. The persistence of Dimilin has been verified in laboratory studies using simulated rain of several inches and documented in field studies that have monitored rain run-off have found only trace amounts of Dimilin (parts per trillion) in streams.

As mentioned above, Dimilin will still be on the foliage and should be effective against older larvae which move from heavily defoliated areas in search of food. This protection has been demonstrated by the treatment of road corridors along the Skyline Drive in the Shenandoah National Park. The Park treats a swath of 200 feet on both sides of the Drive. This approach has protected the trees despite very high gypsy moth populations adjacent to the treated area.

The persistence of Dimilin, while being favorable for protection, is also of concern. Dimilin is not selective, it is effective against many different plant eating insects. Due to its longevity on foliage and broad spectrum activity, it affects many non-target organisms throughout the year. While this may not be as critical in residential communities, in the uninhabited forest it may adversely affect other insect communities and also those organisms that depend on these insects as a food source.

THE GYPSY MOTH RESEARCH AND DEVELOPMENT PROGRAM - ALIVE AND WELL

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After almost two years of discussions, planning, writing, and rewriting, the USDA Gypsy Moth Research and Development Program, which operates out of the Northeastern Forest Experiment Station, Radnor, PA, is alive and well and chartered to continue it's activities through September 30, 1995.

But, it won't be business as usual. The focus for the new charter is to bring on line as much new technology as possible by the end of the program and to make it operationally available. Although the mission of the program remains the same, that is to develop the knowledge and technology necessary to maintain gypsy moth populations at economically and socially acceptable levels through IPM techniques, the goals have changed significantly. The program will now concentrate on six goals to provide:

1. Information on the environmental and socioeconomic impacts of gypsy moth and associated management actions.

2. Hazard rating systems for major susceptible forest types.

3. Sampling techniques for decision making.

4. Options to manage gypsy moth and its habitat.

5. Models for predicting defoliation, spread, and dynamics.

6. Decision support for gypsy moth management.

The charter provides narrative to describe the introduction and spread of gypsy moth in North America, the forest resources at risk, and current management philosophy. The essence of the charter is a detailed, goal-by-goal, activity-by-activity narrative of what kind of research will be carried out over the next four years and what is expected in the way of accomplishments.

As the charter was being developed, it was recognized that gypsy moth of Asian origin were present at three locations on the west coast of North America. The introduction of these Asian gypsy moths and their similarities and differences to the European race are discussed in the charter. A meeting of researchers and State and Federal regulatory personnel was held in East Windsor, CT, in November 1991 to establish research needs. Much of what we know about the European race and research proposed in the charter on it also applies to the Asian race. It does have some behavioral and physiological differences though that must be examined if we are to effectively eradicate this race of gypsy moth from North America. A brief narrative of proposed research on the Asian race is included in the charter and much of this work has already been implemented.

The mission and goals described in the charter were developed in cooperation with State and Private Forestry, Forest Health Protection/Forest Pest Management, and as mentioned above, are directed at supplying that organization and other user groups with the most timely and most needed technology to manage gypsy moth in areas where it has been established for many years, along the advancing front, in widely isolated populations, or in new introductions as in the case of the Asian gypsy moth. Our research will stress technology transfer and quick hand-off of new or refined methods in all the goal areas identified.

Finally, the charter stressed the need for continuing cooperation with other parts of the Forest Service, other agencies in the Department of Agriculture, State agencies, industry, and universities. The Gypsy Moth Research and Development Program will cooperate with all interested parties to assure that the highest priority research needs are being addressed and all resources available are being maximized. In short, the program is revitalized and alive and well.

USDA FOREST SERVICE GYPSY MOTH RESEARCH AND DEVELOPMENT PROGRAM

Research funded by the Gypsy Moth Research and Development (GMR&D) Program in FY 1991 was conducted by scientists in- and outside of the USDA Forest Service, with studies directed at increasing our knowledge of and developing technologies in the following areas:

1. Effects of gypsy moth on forests;

2. Gypsy moth biology and population dynamics;

3. Management control options, especially the use of microbials;

4. Models and integration of knowledge.

Listed below are study titles by program objective.

PROGRAM OBJECTIVE 1: GYPSY MOTH EFFECTS ON FORESTS

Studies were funded to investigate gypsy moth defoliation and treatment effects on forests. Research under this program objective is aimed at the following components of the forest ecosystem: a.) Tree growth and mortality, b.) Secondary pests, c.) Economics, and d.) Nontimber resources.

1a. Tree Growth and Mortality

Impacts of gypsy moth defoliation on mixed pine-hardwood stands in Virginia and Maryland. C.B. Davidson and J.D. Johnson, Virginia Polytechnic Institute and State University, Blacksburg, VA.

Effects of previous stand management on tree mortality following gypsy moth defoliation. K.W. Gottschalk, NEFES, USDA, FS, Morgantown, WV.

Effects of low gypsy moth egg mass densities on shelterwood and seed tree cuts on the Allegheny National Forest. K.W. Gottschalk and A.M. Liebhold, NEFES, USDA, FS, Morgantown, WV.

Central Pennsylvania gypsy moth risk-rating/impact plot network. M. Twery, USDA, FS, NEFES, Morgantown, WV.

Impacts of gypsy moth in pine/hardwood stands. M. Twery and K. Gottschalk, USDA, FS, NEFES, Morgantown, WV.

Development of improved models for predicting gypsy moth defoliation. A. Liebhold, USDA, FS, NEFES, Morgantown, WV ; E. Simons and A. Sior, Pennsylvania Bureau of Forestry, Division of Pest Management, Middletown, PA.

Impact of gypsy moth defoliation on hydrology and water quality in northcentral West Virginia. R.R. Hicks, Jr., West Virginia University, Morgantown, WV.

Susceptibility and vulnerability of mixed oak clearcuts to gypsy moth. R.R. Hicks, Jr. and D.E. Fosbroke, West Virginia University, Morgantown, WV.

Interaction of natural levels of environmental stress and defoliation on oak survival, photosynthesis and growth. J. McGraw, West Virginia University, Morgantown, WV; and K. Gottschalk, USDA FS, NEFES, Morgantown, WV.

Soil nutrients and small tree growth before and after gypsy moth arrival in Southwestern Pennsylvania. C.A. Walter, St. Vincent College, Latrobe, PA, and Carnegie Museum of Natural History, Pittsburgh, PA.

1b. Secondary Pests

Relate abundance of rhizomorphs of armillaria in the soil to abundance on crop trees and subsequent mortality after defoliation. P.M. Wargo and M. Twery, USDA, FS, NEFES, Hamden, CT and Morgantown, WV.

Impacts of secondary organisms on tree mortality after thinning and defoliation. M. Twery and P. Wargo, USDA, FS, NEFES, Hamden, CT and Morgantown, WV.

Evaluation of Lindgren funnel traps and different attractants for sampling two-lined chestnut borer. M. Twery and D. Jennings, USDA, FS, NEFES, Morgantown, WV .

Impact of small mammal predators on gypsy moth populations in selected habitats of the Southeast. F. P. Hain, North Carolina State University, Raleigh, NC.

1c. Economics

Effects of gypsy moth defoliation on public outdoor recreation area visitation and public opinion regarding gypsy moth suppression. S. Hollenhorst and S. Brock, West Virginia University, Morgantown, WV.

PROGRAM OBJECTIVE 2: GYPSY MOTH BIOLOGY AND POPULATION DYNAMICS

Studies were funded to investigate gypsy moth biology and population dynamics in FY 1991. Research on this program objective included the study of: a.) biology, b.) population monitoring,

c.) regulation by natural enemies, and d.) host plant/forest stand effects on gypsy moth population dynamics.

2a. Biology

Genetic improvement of colonized gypsy moth used for mass production of F_1-sterile egg masses, virus production, and research: Artificial selection for favorable characteristics. M. Keena, USDA, FS, NEFES, Hamden, CT.

Effects of an alternating temperature rearing regime on gypsy moth life history trains. M. Keena and S. Taylor, USDA, FS, NEFES, Hamden, CT.

F_1-hybrids between wild and laboratory strains of gypsy moth: A field evaluation of the usefulness for the F_1-sterile egg mass program. M. Keena and T. O'Dell, USDA, FS, NEFES, Hamden, CT.

Effect of wheat germ age on fatty acid composition of prepared gypsy moth over time, and the consequences of the effect on offspring of insects feeding on the diet. T.M. O'Dell, T.W. Culliney, and D. Roberts, USDA, FS, NEFES, Hamden, CT.

Genetic improvement of colonized gypsy moth used for mass production of F_1-sterile egg masses, virus production and research. C.S. Henry and M.A. Keena, USDA, FS, NEFES, Hamden, CT.

2b. Population Monitoring

Development of a gypsy moth monitoring system based on counts under burlap bands. J.S. Elkinton, University of Massachusetts, Amherst, MA.

2c. Regulation of Gypsy Moth by Natural Enemies

Nucleopolyderosis virus dynamics in gypsy moth populations. J.S. Elkinton and J.P. Burand, University of Massachusetts, Amherst, MA.

Introduction and spread of *Entomophaga maimaiga* in the Southern Appalachians. A.E. Hajek, Boyce Thompson Institute for Plant Research, Ithaca, NY; and J.S. Elkinton, University of Massachusetts, Amherst, MA.

2d. Host-Plant/Forest Stand Effects

Management of gypsy moth in Vermont focal areas. B.L. Parker and J. Rosovsky, University of Vermont, Burlington, VT.

The importance of synchrony between gypsy moth and host phenology. A. Liebhold, USDA, FS, NEFES, Morgantown, WV.

Performance of gypsy moth on trees indigenous to the southern United States: Egg hatch and host tree phenology. C.W. Berisford, University of Georgia, Athens, GA.

The effects of host tree phenology and host switching on the gypsy moth. J.A. Witter, University of Michigan, Ann Arbor, MI.

Interactive effects of foliar ascorbic acid and phenolics on the gypsy moth (Lymantria dispar). R.L. Lindroth, University of Wisconsin, Madison, WI.

PROGRAM OBJECTIVE 3: GYPSY MOTH MANAGEMENT

Studies were directed toward the development of gypsy moth management options, including treatments utilizing: a.) microbials (virus, *B.t.* and microsporidia); b.) aerial application; c.) population monitoring; d.) inherited sterility; and e.) silvicultural treatments.

3a. Microbials

Evaluation of gypsy moth NPV strains and potency enhancers in small field plots using ground hydraulic equipment. J. Podgwaite, USDA, FS, NEFES, Hamden, CT; R. Webb and M. Shapiro, ARS Insect Pathology Lab, Beltsville, MD.

Predicting the spread of engineered virus. J.S. Elkinton, G. Dwyer and J. Burand, University of Massachusetts, Amherst, MA.

Bacillus thuringiensis

Toxicity to gypsy moth delta-endotoxin proteins from three *B. thuringiensis* genes associated with coding of delta-endotoxin of Strain HD-1, HD-73,

and NRD-12 (HD-945). N. Dubois, USDA, FS, NEFES, Hamden, CT.

Correlation between vesicle binding efficiency of brush border membranes of proteins from CryIA(a), CryIA(b), and CryIA(c) genes cloned in *E. coli* and their toxicity to gypsy moth larvae with and without HD-73 Cry *B. thuringiensis* spores. N. Dubois, USDA, FS, NEFES, Hamden, CT; D. Dean, Ohio State University, Columbus, OH; and M. Wolfersberger, Temple University, Philadelphia, PA.

Comparative efficacy of *Bacillus thuringiensis* (Foray 48B) applied by mist blower and/or hydraulic sprayer on small blocks infested with gypsy moth. N. Dubois, USDA, FS, NEFES, Hamden, CT; and W. McLane, USDA, APHIS, S&T, Otis AFB, MA.

Impact of *B.t.* on native Lepidoptera on the Goshen Wildlife Management Area, Rockbridge County, Virginia. J. Peacock, USDA, FS, NEFES, Hamden, CT.

Gypsy moth specific *Bacillus thuringiensis* -endotoxins: Improvement by site-directed mutagenesis. D.H. Dean, Ohio State University, Columbus, OH; and N.R. Dubois, USDA, FS, NEFES, Hamden, CT.

Microsporidia

Genetic engineering and field release of *Lymantria dispar* nuclear polyhedrosis virus. H.A. Wood, Boyce Thompson Institute for Plant Research, Ithaca, NY.

Detection of latent nuclear polyhedrosis virus in the gypsy moth. J.P. Burand and J.S. Elkinton, University of Massachusetts, Amherst, MA.

3b. Aerial Application

Studies in aerial application technology relating to the improvement of suppression of the gypsy moth, K. Mierzejewski, M.L. McManus, N.R. Dubois, W. McLane, W.G. Yendol, S. Maczuga and P.M. Nealen, The Pennsylvania State University, University Park, PA.

Micrometerorological measurements for critical analysis and evaluation of the NE Spray Research Trials. D.R. Miller and D. E. Anderson, University of Connecticut, Storrs, CT.

Evaluation of double applications of Gypchek and *B.t.* against low density gypsy moth populations in the George Washington National Forest. J. Podgwaite and N. Dubois, USDA, FS, NEFES, Hamden, CT; R. Reardon, USDA, FS, NA-S&PF, Morgantown, WV; and J. Witcosky, USDA FS, R-8, Harrisonburg, VA.

Evaluation of Gypchek formulations against gypsy moth populations in Virginia. J. Podgwaite, USDA, FS, NEFES; R. Reardon, AIPM Demo Project, Morgantown, WV; J. Cunningham, FPMI, Canada.

3c. Populations Monitoring

Evaluation of fixed-time and fixed-distance walks as methods for estimating gypsy moth egg mass densities. A.Liebhold , USDA, FS, NEFES, Morgantown, WV; D. Twardus, USDA, FS, NA, S&PF, FHP, Morgantown, WV; J. Buonaccorsi, University of Massachusetts, Amherst, MA.

Development of a gypsy moth population monitoring system: Sampling egg masses in IPM programs. F.W. Ravlin, J.L. Carter and S.J. Fleischer, VPI & SU, Blacksburg, VA.

Development of an efficient gypsy moth sampling protocol for forests and suburban areas. M. Scriber, C.A. Chilcote, Michigan State University, East Lansing, MI.

3d. Inherited Sterility

3e. Silvicultural Treatments

Effects of silvicultural treatments on growth, mortality, and regeneration in gypsy moth defoliated mixed-oak hardwood stands. K.W. Gottschalk, USDA, FS, NEFES, Morgantown, WV.

Testing and evaluation of silvicultural guidelines for gypsy moth, K.W. Gottschalk. USDA, FS, NEFES, Morgantown, WV.

Evaluation of presalvage and sanitation thinnings for minimizing gypsy moth impacts. K.W. Gottschalk and M.J. Twery, USDA, FS, NEFES, Morgantown, WV.

Testing and evaluation of silvicultural guidelines for gypsy moth in the AIPM area. K.W. Gottschalk, USDA, FS, NEFES, Morgantown, WV.

Effect of silvicultural manipulations on gypsy moth population dynamics. A. Liebhold, USDA, FS, NEFES, Morgantown, WV.

Evaluation of hazard rating and silvicultural treatments to minimize gypsy moth impacts at the West Virginia Forest. R.R. Hicks, Jr., West Virginia University, Morgantown, WV.

OBJECTIVE 4: MODELS AND INTEGRATION OF KNOWLEDGE

4a. Simulation Models

Landscape study of gypsy moth spatial dynamics. A. Liebhold, USDA, FS, NEFES; G. Elmes, West Virginia University, Morgantown, WV; and M. Hohn, West Virginia Geological and Economic Survey, Morgantown, WV.

Geostatistical models for forecasting gypsy moth defoliation. M.E. Hohn, West Virginia Geological and Economic Survey, Morgantown, WV.

Maps of seasonal gypsy moth development using phenology models and high resolution temperature data. J.M. Russo, ZedX, Inc.

Updating and evaluating the gypsy moth life system model (GMLSM). J.J. Colbert, USDA FS, NEFES, Morgantown, WV.

Development and analysis of a differential equation model of gypsy moth population dynamics, as well as the restructuring of the Gypsy Moth Life System Model. J.W. Wilder, West Virginia University, Morgantown, WV; and J.J. Colbert, USDA, FS, NEFES, Morgantown, WV.

Factors contributing to the dynamics of gypsy moth populations. J.J. Colbert, USDA FS, NEFES, Morgantown, WV; and A. Sharov, West Virginia University, Morgantown, WV.

Development of a predictive model of gypsy moth egg phenology. J.A. Logan, D.R. Gray, F.W. Ravlin, VPI & SU, Blacksburg, VA.

Refinement of the gypsy moth larval phenology model using field data. J.A. Logan, J.L. Smith, VPI & SU, Blacksburg, VA.

4b. Expert Systems

Development of GypsES, a decision support system for gypsy moth management. M. Twery, USDA FS, NEFES, Morgantown, WV.

Development of integration of the Treatment Advisor in GypsES. M.C. Saunders and M.A. Foster, The Pennsylvania State University, University Park, PA.

Development of a knowledge-based geographic information system: A component of the GypsES system. G.A. Elmes and C.B. Yuill, West Virginia University, Morgantown, WV.

Monitoring system designer, defoliation predictor and phenology predictor components of GypsES. F.W. Ravlin, J.A. Logan and L.P. Schaub, VPI & SU, Blacksburg, VA.

AIPM METHODS IMPROVEMENT, PILOT PROJECTS, SPECIAL PROJECTS, AND SUPPORTIVE METHODS FUNDED IN 1992

Richard Reardon
AIPM Project Leader
USDA Forest Service
Morgantown, WV 26505

In 1987, Congress provided a supplemental appropriation to the USDA Forest Service to initiate the Appalachian Integrated Pest Management (AIPM) Gypsy Moth Demonstration Project (the program is expected to terminate in March of 1993). This project is aimed at slowing the spread and minimizing the impact of the gypsy moth along the Allegheny Mountains in Virginia and West Virginia. A major focus of the AIPM project is the

development of a model Integrated Pest Management Program in a large geographic area. A system that uses a variety of methods to manage gypsy moth populations in an environmentally sound manner will prove invaluable as the gypsy moth moves into the Southern hardwood region.

One of the major objectives of the AIPM Gypsy Moth Project was to conduct methods improvement, pilot projects, and special projects. These activities supported non-target evaluations and interaction activities which had the potential to become operational and incorporated into the Federal, State, and County Cooperative Suppression Program.

Methods Improvement

Evaluate two commercially-produced "ready to use" formulations in terms of physical properties. J. Podgwaite, USDA, FS, NEFES, Hamden, CT; and J. Cunningham, FPMI, Sault Ste. Marie, Ontario, Canada

Evaluate the standard *B.t.* formulation against low density populations. J. Podgwaite, USDA, FS, NEFES, Hamden, CT.

Evaluate *B.t.* efficacy of single application (maximum dose) against low density populations. N. Dubois, USDA, FS, NEFES, Hamden, CT.

Evaluate efficacy against 3rd and 4th stage larvae. N. Dubois, USDA, FS, NEFES, Hamden, CT; and K. Mierzejewski, NEFAAT, The Pennsylvania State University, University Park, PA.

Continue to evaluate techniques to determine the residual activity of *B.t.* on foliage over time. N. Dubois, USDA, FS, NEFES, Hamden, CT; K. Sundaram, FPMI, Sault Ste, Marie, Ontario, Canada; and K. Mierzejewski, NEFAAT, The Pennsylvania State University, University Park, PA.

Develop an improved operational system for dispensing pheromone flakes, continue monitoring and establish additional plots in Rockbridge County for aerial application of flakes and beads. B. Leonhartd, USDA, ARS, Beltsville, MD; D. Leonard, USDA FS, FPM, Asheville, NC; W. McLane and V. Mastro, USDA, APHIS, Otis AFB, MA; and G.McAninch, VDACS, Harrisonburg, VA.

Continue development and implementation of a large area, standardized gypsy moth IPM package. Includes additional development for ranger districts and counties. F.W. Ravlin, VPI & SU , Blacksburg, VA.

Improve aerial application technology for use during suppression/eradication projects for gypsy moth. W. Yendol, The Pennsylvania State University, University Park, PA.

Special Projects/Supportive Methods

Monitoring and identification of canopy arthropods and aquatic macroinvertebrates in Virginia Big-eared Bat study plots. L. Butler, West Virginia University, Morgantown, WV.

Release and attempted establishment of the fungus *Entomophaga maimaiga* within the AIPM Project area. A. Hajek, Boyce Thompson Institute for Plant Research, Ithaca, NY; and J. Elkinton, University of Massachusetts, Amherst, MA.

B.t.-non-target study in two counties in VA (gypsy moth populations less than 10 egg masses per acre--2nd year) S. Talley, Rockbridge County Coordinator, Staunton, VA, and J. Peacock, USDA, FS, NEFES, Hamden, CT.

B.t.-non-target study in West Virginia--habitats of the Virginia Big-eared Bat. B. Sample, West Virginia University, Morgantown, WV.

Changes in streamwater chemistry and associated impact on trout populations due to gypsy moth defoliation. J. Downey, James Madison University, Harrisonburg, VA.

Effects of gypsy moth defoliation on the aquatic biota of head-water streams in Shenandoah National Park. K. Watson, SNP, VPI & SU, Blacksburg, VA.

Aerial application for gypsy moth suppression: Dimilin accountability in deciduous forests. W. Yendol, The Pennsylvania State University, University Park, PA.

Short-term non-target monitoring in suppression areas. J. Pierce, Environmental Action , Washington, DC.

Incorporate calibration expert system into Swath Kit and develop tool kit for each Kit. J. Bryant, Bio-aeronautical Technologies, Crystal Lake, IL.

Potential cumulative effects of Dimilin on terrestrial litter arthropods in Prince William County, VA. L. Rockwood, George Mason University, Fairfax, VA.

Potential effects of Dimilin on Blue Crab--continuation study supported in part by NAPIAP. S. Reback, University of Maryland, College Park, MD.

Impact of the fungus Entomophaga maimaiga on non-target lepidoptera. A. Hajek, Boyce Thompson Institute for Plant Research, Ithaca, NY; and L. Butler, West Virginia University, Morgantown, WV.

Pilot Projects

Aerial application of low dose/volume on large blocks (evaluated on small plots in 1991). J. Podgwaite, USDA, FS, NEFES, Hamden, CT; and J.Cunningham, FPMI, Sault Ste. Marie, Ontario, Canada.

Silviculture/low-level intervention activities. J. Hedrick, USDA, FS, Jefferson NF, Natural Bridge Station, VA.

Aerial application of Dimilin to closed watersheds and continue non-target monitoring (all 3rd or 4th year evaluations).

Effects of Dimilin on Stream Salamanders. T. Pauley, Marshall University, Huntington, WV.

A comparative study of growth rates, survivorship and population dynamics of terrestrial salamanders. T. Pauley, Marshall University, Huntington, WV.

Effects of Dimilin on the canopy arthropod fauna. L. Butler, West Virginia University, Morgantown, WV.

Effects of Dimilin on the soil microflora. J. Landolt, Shepherd College, Shepherdstown, WV.

Effects of Dimilin on aquatic macroinvertebrates--field monitoring. S. Perry, West Virginia University, Morgantown, WV.

Effects of Dimilin on leaf litter arthropods. B. Perry, West Virginia University, Morgantown, WV.

Effects of Dimilin on aquatic macroinvertebrates--laboratory studies. S. Perry, West Virginia University, Morgantown, WV.

Effects of Dimilin on pollinators. E. Barrows, Georgetown University, Washington, DC.

Effects of Dimilin on aquatic fungi. T. Dubey, Shepherd College, Shepherdstown, WV.

Dimilin residue analysis (leaves, litter, etc.) M. Wimmer, West Virginia University, Morgantown, WV.

Dimilin residue analysis (water). J. Harper, North Carolina State, Raleigh, NC.

Effects of Dimilin on fungus/leaf shredder complex. K. Cummins, University of Pittsburgh, Pittsburgh, PA.

GYPSY MOTH RESEARCH AT FORESTS CANADA'S FOREST PEST MANAGEMENT INSTITUTE

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Forests Canada, headquartered in Ottawa, is the second smallest Federal government department with about 1,300 employees. Recently, the department's name changed from Forestry Canada to Forests Canada. There are 6 regional laboratories located in St. John's, Newfoundland; Fredericton, New Brunswick; Ste. Foy, Quebec; Sault Ste. Marie, Ontario; Edmonton, Alberta; and Victoria, British Columbia. There are 2 national institutes, the Forest Pest Management Institute (FPMI), which shares a complex with the Ontario Regional Forestry Centre and the National Forestry Research Institute at Petawawa, Ontario, which deal

with tree breeding, remote sensing and forest statistics. FPMI came into existence in 1976 with the amalgamation of the Insect Pathology Research Institute of Sault Ste. Marie and the Chemical Control Research Institute from Ottawa. FPMI has a staff of 85 permanent employees supplemented with 20 to 30 casual employees and summer students. Projects cover all aspects of insect and vegetation control. Our Director General is Dr. E.S. Kondo who is assisted by 3 Program Directors. Gypsy moth is a recent arrival in Ontario. It has been established along the U.S.-Quebec border and on some islands in the St. Lawrence Seaway for many years. It was, and still is, a quarantined insect under the mandate of Agriculture Canada. In 1981, 1,450 hectares (ha) of moderate-to-severe defoliation were reported around Kaladar, north of Kingston. Since then, it has spread through most of southern Ontario and as far north as susceptible hardwood stands are found. Ontario Region staff working in cooperation with FPMI staff and Ontario Ministry of Natural Resources personnel quickly put a research project into place in 1982 to evaluate control options. Gypchek was supplied by Frank Lewis, and *Bacillus thuringiensis* (*B.t.*) and Sevin were also tested against gypsy moth.

Several projects at FPMI are involved directly or indirectly with gypsy moth research. The Insect Production Unit, under the supervision of Bob McCron, supplies about 6,000 gypsy moth egg masses annually to the Pathogen Production Unit, under the supervision of Betty Cunningham, and for research. Bill Kaupp has been instrumental in developing a pathogen production pilot plant and the first product will be gypsy moth virus; there is considerable commercial interest in a gypsy moth viral insecticide. Kees van Frankenhuyzen and his team were involved with *B.t.* field trials in 1987, 1988, and 1989 and are now using gypsy moth as one of the test insects for studying *B.t.* mode of action at the molecular, physiological, and ecological levels. The Environmental Impact Project, under the leadership of Steve Holmes, has studied the effect of *B.t.* on non-target aquatic organisms. This group has recently completed an extensive study on the host range (Lepidoptera) of gypsy moth virus. The Virus Application team, led by John Cunningham, has been particularly active in conducting field trials since 1988 and has treated about 1,000 ha with either Disparvirus produced at the Institute or with Gypchek supplied by USDA Forest Service cooperators. Joint spray trials with Forest Service support were conducted in 1991 and 1992 in collaboration with John Podgwaite and Richard Reardon. FPMI is fortunate to have its own spray plane, piloted by Art Robinson, which is used for these trials. One of the principal achievements of these trials has been a reduction in both the recommended dosage of virus and the emitted volume. A Disparvirus registration petition based on the Gypchek petition was submitted to Agriculture Canada in 1990 and is currently being evaluated.

Gary Grant who leads the pheromone project has been developing a pheromone-based monitoring system to correlate male moth catches with egg mass counts in virus-treated, *B.t.*-treated and untreated check plots. He uses an experimental low release rate lure so as not to flood traps; Barbara Leonhart of the USDA Laboratory at Beltsville, Maryland provides these lures. Blair Helson is working on natural products discovery and development including mechanisms and dynamics of the interactions between forest insect pests and host trees. One of the test insects in his studies is gypsy moth. Arthur Retnakaran has been testing insect growth regulators such as Pyriproxyfen (juvenile hormone analog) and Mimic (ecdysone analog) on eggs and larvae, respectively, of the gypsy moth.

APPROVAL SOUGHT FOR TEST OF GENETICALLY DISABLED GYPSY MOTH VIRUS

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A team of University and Federal researchers has applied to the U.S. Environmental Protection Agency for permission to conduct the first field test of a genetically engineered gypsy moth virus.

H. Alan Wood, a virologist at the Boyce Thompson Institute for Plant Research, said the virus has been genetically transformed so that it will not persist in the environment. Also, the virus does not infect humans or other vertebrate animals. Pending approval, release is scheduled for spring 1993 at Otis Air National Guard Base, a National Guard facility in Cataunet, MA, on Cape Cod.

If approved, the test will be the second field trial in the United States of a genetically altered insect virus. Wood conducted the first test in 1989, demonstrating that the genetic code of a virus could be altered so that it would not persist in the environment.

The current project is a collaboration headed by Wood. The other scientists participating in the project are James Slavicek of the Biotechnology Laboratory of the USDA, Forest Service in Delaware, OH; Joseph Elkington and John Burand of the University of Massachusetts; and Michael McManus and John Podgwaite of the USDA Forest Service in Hamden, CT.

The unaltered virus (*Lymantria dispar* nuclear polyhedrosis virus), a registered pesticide developed by the USDA Forest Service researchers, has caused no detectable disturbances to the environment or health problems, according to Wood. Since 1978, it has been sprayed on thousands of acres of forests in the northeastern United States to reduce damage to hardwood forests. Gypsy moths are its sole target in this region.

Naturally occurring, the virus becomes most active when gypsy moth populations soar. Typically, an outbreak of the virus will kill more than 90 percent of gypsy moth larvae, leading to a crash in the gypsy moth population.

"Since we have had outbreaks of this virus in the Northeast for more than 100 years, its safety is well-established," Wood said.

Safety is one purpose of the proposed experiment, which is designed to demonstrate further Wood's experience that disabled genetically engineered viruses will not persist in the environment. This trait is desirable because it enables researchers to guarantee that altered organisms will not live and spread indefinitely. Wood's 1989 field test, which first used a disabled virus to limit survival, involved a virus released in an environment of agricultural row crops. The test, performed at Cornell's New York State Agricultural Experiment Station in Geneva, NY, used a virus that attacks the cabbage looper, a pale green worm that feeds on vegetables. None of the altered virus has survived until now, he said.

The proposed experiment on Cape Cod is similar in that Boyce Thompson researchers have removed a gene from the naturally occurring gypsy moth virus that provides it with a protective covering. Without the covering, the virus cannot persist.

The researchers chose the Cape Cod site, according to Wood, because it contains large stands of scrub oak, one of the gypsy moth's preferred hosts. The scrub oak also is low enough to facilitate sample collection. The release site will be located a least a mile from any dwellings or fresh water sources.

Researchers will measure the rate of disappearance of the virus in the environment--this time a wooded landscape instead of an agricultural field. They also have added a genetic tag to the virus so that gypsy moths infected by the engineered virus can be identified in the field; they turn blue with an easy-to-perform test.

"This tag will provide foresters with a rare opportunity to learn more about the ecology of the gypsy moth virus," Wood said. "Normally, it's impossible to distinguish between gypsy moths that have been infested by the naturally occurring virus versus one that has been introduced for test

purposes. In contrast, we will know exactly how this virus has spread."

The genetic tag consists of an inserted gene, called lac Z, that initiates production of beta-galactosidase, a non-toxic substance commonly found in nature. The method for detecting beta-galactosidase is fast, simple and inexpensive, Wood said.

The Boyce Thompson Institute is the only major private, independent research institute focused exclusively on plant research in the United States. The Institute was founded in 1924 in Yonkers, NY, and moved to the Cornell University campus in 1978. Funding for this project is being provided by the USDA Forest Service.

For more information, contact William Holder in his office at 607-255-3290.

NEW PUBLICATIONS

Aerial application of racemic disparlure to manage low-level populations of gypsy moth, 1989 by Donna S. Leonard, Barbara A. Leonhardt, Win H. McLane, John H. Ghent, Sheryl K. Parker, Timothy J. Roland, and Richard C. Reardon. 1992. USDA For. Serv. Tech. Paper. NA-TP-04-92. 16pp.

This report documents the use of aerially applied racemic disparlure to control an isolated infestation of gypsy moths in Giles County, Virginia.

Gypsy moth impact on Virginia's hardwood forests and forest industry by Tim Tigner. 1992. Virginia Dept. of Forestry, Charlottesville, VA. 36pp.

This report describes the potential impact of gypsy moth on Virginia's susceptible forest land.

Gypsy moth suppression in the Northeast--Summary of the Treatment Monitoring Data Base, 1989-1990 by Daniel B. Twardus and Helen A. Machesky. 1992. USDA For. Serv. Tech. Paper. NA-TP-08-92.

This report summarizes gypsy moth project effectiveness in meeting objectives, 1989-1990.

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